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THE UNITED STATES OF AMERICA

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United States Patent and Trademark Office

June 22, 2005

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.

APPLICATION NUMBER: *60/377,344*
FILING DATE: *May 02, 2002*
RELATED PCT APPLICATION NUMBER: *PCT/US03/11928*

Certified by

Jon W. Dudas

Under Secretary of Commerce
for Intellectual Property
and Director of the United States
Patent and Trademark Office

05-03-02

A/PROV

Practitioner's Docket No. NPV PAT005US

PATENT

Preliminary Classification:
Proposed Class:
Subclass:

NOTE: *"All applicants are requested to include a preliminary classification on newly filed patent applications. The preliminary classification, preferably class and subclass designations, should be identified in the upper right-hand corner of the letter of transmittal accompanying the application papers, for example 'Proposed Class 2, subclass 129.'" M.P.E.P., § 601, 7th ed.*

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: VALENTI et al

For: WELL CASING WITH ANGLED PERFORATIONS

Box Provisional Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

COVER SHEET FOR FILING PROVISIONAL APPLICATION
(37 C.F.R. § 1.51(c)(1))

WARNING: *"A provisional application must also include the cover sheet required by § 1.51(c)(1) or a cover letter identifying the application as a provisional application. Otherwise , the application will be treated as an application filed under paragraph (b) [nonprovisional application] of this section." 37 C.F.R. § 1.53(c)(1). See also M.P.E.P. § 201.04(b), 6th ed., rev. 3.*

CERTIFICATION UNDER 37 C.F.R. §§ 1.8(a) and 1.10*
(When using Express Mail, the Express Mail label number is ***mandatory;*** *Express Mail certification is optional.)*

I hereby certify that, on the date shown below, this correspondence is being:

MAILING

☒ deposited with the United States Postal Service in an envelope addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231

37 C.F.R. § 1.8(a)

☐ with sufficient postage as first class mail.

37 C.F.R. § 1.10 *

☒ as "Express Mail Post Office to Addressee"
Mailing Label No. EU224544178US **(mandatory)**

TRANSMISSION

☐ facsimile transmitted to the Patent and Trademark Office, (703) ________

Date: 2 May 2002

[signature] Cameron
Signature

____
(type or print name of person certifying)

** Only the date of filing (§ 1.6) will be the date used in a patent term adjustment calculation, although the date on any certificate of mailing or transmission under § 1.8 continues to be taken into account in determining timeliness. See § 1.703(f). Consider "Express Mail Post Office to Addressee" (§ 1.10) or facsimile transmission (§ 1.6(d)) for the reply to be accorded the earliest possible filing date for patent term adjustment calculations.*

NOTE: *"A complete provisional application does not require claims since no examination on the merits will be given to a provisional application. However, provisional applications may be filed with one or more claims as part of the application. Nevertheless, no additional claim fee or multiple dependent claims fee will be required in a provisional application." Notice of December 5, 1994, 59 Fed. Reg. 63,951, at 63,953.*

"Any claim filed with a provisional application will, of course, be considered part of the original provisional application disclosure." Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,209.

NOTE: *"A provisional application is not entitled to the right of priority under 35 U.S.C. 119 or 365(a) or § 1.55, or to the benefit of an earlier filing date under 35 U.S.C. 120, 121 or 365(c) or § 1.78 of any other application. No claim for priority under § 1.78(a)(3) may be made in a design application based on a provisional application. No request under § 1.293 for a statutory invention registration may be filed in a provisional application. The requirements of §§ 1.821 through 1.825 regarding application disclosures containing nucleotide and/or amino acid sequences are not mandatory for provisional applications." 37 C.F.R. § 1.53(c)(3).*

NOTE: *"No information disclosure statement may be filed in a provisional application." 37 C.F.R. § 1.51(d). "Any information disclosure statements filed in a provisional application would either be returned or disposed of at the convenience of the Office." Notice of December 5, 1994, 59 Fed. Reg. 63,591, at 63,594.*

NOTE: *"No amendment other than to make the provisional application comply with the patent statute and all applicable regulations may be made to the provisional application after the filing date of the provisional application." 37 C.F.R. § 1.53(c).*

NOTE: *35 U.S.C. 119(e) provides that "[i]f the day that is 12 months after the filing date of a provisional application falls on a Saturday, Sunday, or Federal Holiday within the District of Columbia, the period of pendency of the provisional application shall be extended to the next succeeding secular or business day."*

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 C.F.R. § 1.51(c)(1)(i).

1. The following comprises the information required by 37 C.F.R. § 1.51(c)(1):

2. The name(s) of the inventor(s) is/are (37 C.F.R. § 1.51(c)(1)(ii)):

NOTE: *"If the correct inventor or inventors are not named on filing a provisional application without a cover sheet under § 1.15(c)(1), the later submission of a cover sheet under § 1.15(c)(1) during the pendency of the application will act to correct the earlier identification of inventorship." 37 C.F.R. § 1.48(f)(2).*

NOTE: *"The naming of inventors for obtaining a filing date for a provisional application is the same as for other applications. A provisional application filed with the inventors identified as 'Jones et al.' will not be accorded a filing date earlier than the date upon which the name of each inventor is supplied unless a petition with the fee set forth in § 1.17(i) is filed which sets forth the reasons the delay in supplying the names should be excused. Administrative oversight is an acceptable reason. It should be noted that for a 35 U.S.C. 111(a) application to be entitled to claim the benefit of the filing date of a provisional application the 35 U.S.C. 111(a)[,] application must have at least one inventor in common with the provisional application." Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,209.*

The term "invention" is typically used to refer to subject matter which applicant is claiming in his/her application. Because claims are not required in a provisional application, it would not be appropriate to reference joint inventors as those who have made a contribution to the "invention" disclosed in the provisional application. If the "invention" has not been determined in the provisional application because no claims have been presented, then the name(s) of those person(s) who have made a contribution to the subject matter disclosed in the provisional application should be submitted. Section 1.45(c) states that "if multiple inventors are named in a provisional application, each named inventor must have made a contribution, individually or jointly, to the subject matter disclosed in the provisional application." All that § 1.45(c) requires is that if someone is named as an inventor, that person must have made a contribution to the subject matter disclosed in the provisional application. When applicant has determined what the invention is by the filing of the 35 U.S.C. 111(a) application, that is the time when the correct inventors must be named. The 35 U.S.C. 111a) application must have an inventor in common with the provisional application in order for the 35 U.S.C. 111(a) application to be entitled to claim the benefit of the provisional application under 35 U.S.C. 119(e). Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,208.

See 37 C.F.R. § 1.53.

1. NICHOLAS | P | VALENTI
GIVEN NAME | MIDDLE INITIAL OR NAME | FAMILY (OR LAST) NAME

2. RICHARD | M | VALENTI
GIVEN NAME | MIDDLE INITIAL OR NAME | FAMILY (OR LAST) NAME

3. ______ | ______ | ______
GIVEN NAME | MIDDLE INITIAL OR NAME | FAMILY (OR LAST) NAME

3. Residence address(es) of the inventor(s), as numbered above (37 C.F.R. § 1.51(c)(1)(iii)):
1. 1442 Kingwood Drive, #157, Kingwood, TX 77339
2. 1442 Kingwood Drive, #157, Kingwood, TX 77339
3. ______

4. The title of the invention is (37 C.F.R. § 1.51(c)(1)(iv)):
WELL CASING WITH ANGLED PERFORATIONS

5. The name, registration, customer and telephone numbers of the practitioner *(if applicable)* is (37 C.F.R. § 1.51(c)(1)(v)):

Name of practitioner: John R Casperson

Reg. No. 28198 Tel. (281) 482 2961

Customer No. ______

(complete the following, if applicable)

☐ A power of attorney accompanies this cover sheet.

6. The docket number used to identify this application is (37 C.F.R. § 1.51(c)(1)(vi)):

Docket No.: NPVPAT005US

7. The correspondence address for this application is (37 C.F.R. § 1.51(c)(1)(vii)):
John R Casperson
PO Box 2074, Friendswood, TX 77549

8. Statement as to whether invention was made by an agency of the U.S. Government or under contract with an agency of the U.S. Government.
(37 C.F.R. § 1.51(c)(1)(viii))

This invention was made by an agency of the United States Government, or under contract with an agency of the United States Government.

☒ No.

☐ Yes.
The name of the U.S. Government agency and the Government contract number are: ______

09377344.050202

9. Identification of documents accompanying this cover sheet:

A. Documents required by 37 C.F.R. §§ 1.51(c)(2)–(3):

Specification: (including claims) No. of pages 11

Drawings: No. of sheets 2

B. Additional documents:

☐ Claims: No. of claims _____

Note: See 37 C.F.R. § 1.51.

☐ Power of attorney

☐ Small entity assertion

☐ Assignment

☐ Other

NOTE: Provisional applications may be filed in a language other than English as set forth in existing § 1.52(d). However, an English language translation is necessary for security screening purposes. Therefore, the PTO will require the English language translation and payment of the fee mandated in § 1.52(d) in the provisional application. Failure to timely submit the translation in response to a PTO requirement will result in the abandonment of the provisional application. If a 35 U.S.C. 111(a) application is filed without providing the English language translation in the provisional application, the English language translation will be required to be supplied in every 35 U.S.C. 111(a) application claiming priority of the non-English language provisional application. Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,209.

10. Fee

The filing fee for this provisional application, as set in 37 C.F.R. § 1.16(k), is $160.00, for other than a small entity, and $80.00, for a small entity.

☒ Applicant is a small entity.

*NOTE: "A. . . statement in compliance with existing § 1.27 is required to be filed in **each** provisional application in which it is desired to pay reduced fees." Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,197.*

11. Small entity assertion

☐ The assertion that this is a filing by a small entity under 37 C.F.R. § 1.27(c)(1) is attached. ("ASSERTION OF SMALL ENTITY STATUS")

☒ Small entity status is asserted for this application by payment of the small entity filing fee under § 1.16(k). 37 C.F.R. § 1.27(c)(3).

12. Fee payment

☒ Fee payment inthe amount of $ 80.00 is being made at this time.

☐ No filing fee is to be paid at this time. (This and the surcharge required by 37 C.F.R. 1.16(l) can be paid subsequently).

13. Method of fee payment

- ☐ Attached is a ☒ check ☐ money order in the amount of $ 80.00
- ☐ Authorization is hereby made to charge the amount of $ ______
  - ☐ to Deposit Account No. ______
  - ☐ to Credit card as shown on the attached credit card information authorization form PTO-2038.

WARNING: *Credit card information should **not** be included on this form as it may become public.*

- ☐ Charge any additional fees required by this paper or credit any overpayment in the manner authorized above.

A duplicate of this paper is attached.

Date: ______

Tel.: ( )

______
Signature of submitter

OR

______
Signature of practitioner

Date: 5-2-02

Reg. No.: 28198

Tel.: (281) 482 2961

Customer No.:

John R Casperson
(type or print name of practitioner)

Po Box 2174
P.O. Address
Friendswood, TX 77549

APPLICATION FOR PATENT

INVENTORS:
NICHOLAS P. VALENTI
RICHARD M. VALENTI

TITLE: WELL CASING WITH ANGLED PERFORATIONS

SPECIFICATION

BACKGROUND OF THE INVENTION

The invention relates generally to the reduction of flow resistance of fluids flowing from a production zone and along a cased wellbore.

Much attention and engineering has been performed to address the flow resistance that occurs as a result of fluid flowing into a cased wellbore. Solutions to minimize the flow resistance include such efforts as wellbore damage remediation, fracture stimulation, gravel packing and horizontal completions. All of these efforts attempt to address the flow resistance that occurs between the reservoir and the center of the wellbore. For a typical vertical well completion, this is the primary source of the flow resistance. However, for a horizontal well completion, under certain conditions, there is also relatively significant flow resistance along the axis of the wellbore, from the toe to the heel.

The nature of the flow resistance that occurs within the horizontal completion is due to the ingress of fluid along the length of the horizontal wellbore. Usually, within the wellbore, due to low fluid velocities, fluids are flowing in the laminar regime. As a result the fluid flowlines run parallel to the axis of the wellbore. This of course, is a valid assumption in the casing with exception of the completion interval.

In the completion interval, fluid flows into and along the cased wellbore. The flow into the wellbore is generally radially inward, which is perpendicular to the flow direction of fluids within the wellbore. Phrased another way, the perfs through the casing open so that the perf axis points directly (normally) toward the longitudinal axis of the casing. The perfs are generally positioned along a 360 degree arc or band around the circumference of the liner at spaced apart longitudinal positions. The continuous ingress along the entire length of the wellbore completion interval prevents laminar flow and causes the fluid flow in the horizontal wellbore to resemble turbulent flow. However, this turbulent flow is not due to high fluid velocities, but rather, it is due to non-parallel flowlines.

In conventional, vertical wells the flow resistance occurring along the length of the completion is assumed negligible because the typical length of the completion is usually on the order of 10's of feet. This compares to the 1000's of feet of casing between the wellhead and producing interval. However, for horizontal wells, the length of the completion can be as long as the vertical depth of the well. It is common industry practice to have horizontal completions that are 100's to 1000's of feet in length. Due to this substantially longer completion interval, for a horizontal well in comparison to the vertical well, the flow resistance occurring along the length of the completion is no longer insignificant.

The flow resistance along the length of the completion is sufficiently large to result in a non-uniform inflow of fluids along the length of the completion. An SPE (Society of Petroleum Engineering) Paper published in 1996 by Tang, Ozkan, Kelkar, Sarica and Yildiz shows the significance of this flow resistance. These findings are based on their work, which was organized as a joint industry project, titled: "Optimization of Horizontal-Well Completion II." As presented in the SPE paper, the fluid flow into the wellbore is non-uniform. The highest contribution of fluid is at the heel of the completion. The fluid rate at the heel is more than four times the fluid rate at the center of the completion and almost two times the fluid rate at the toe of the completion. This variation in fluid inflow is due to the flow resistance

resulting from non-parallel flowlines within the wellbore. The fluid flow paths literally collide with each other within the wellbore, which results in the turbulent-like fluid flow behavior.

A new perforation technique designed to minimize the flow resistance that occurs due to the confluence of flow into the wellbore would be very desirable. Such a technique would be expected to provide the greatest benefit for horizontal wells due to the length of their completions. However, the techniques would also be beneficial for vertical wells with long and/or commingled completions.

SUMMARY OF THE INVENTION

In one embodiment of the invention, there is provided a well for the production of hydrocarbons having a casing which has been perfed to provide low resistance to flow across the completion zone. The well comprises a well bore and a casing. The well bore extends into the earth from the surface of the earth into a hydrocarbon production zone. The well bore casing is positioned in the borehole and has a longitudinal axis, a generally annular cross section across the longitudinal axis, a wellhead end, a well bottom end, and a plurality of perforations opening through a sidewall of the casing along a segment of the casing positioned in the hydrocarbon production zone. The perforations form plurality of flow paths from an outer surface of the casing to an inner surface of the casing and are formed through the sidewall at an obtuse angle with respect to the longitudinal axis of the casing in the direction of the wellhead end so that substantially all hydrocarbon flowing from the hydrocarbon production zone and into the casing exits the perforations with a substantial axial velocity component toward the wellhead end of the casing.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic illustration of a casing segment in accordance with a preferred embodiment of the invention which is provided with perforations angled axially to reduce flow resistance due to influx across a completion interval of a well.

Figure 2 is a longitudinal section of a well segment in accordance with a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The objective of the invention is to smoothly merge the influx flow streams with the cased wellbore flow stream so as to reduce the flow resistance along the perforated section of the wellbore casing. The invention employs a casing perfed for angled fluid influx to accomplish this. By perfed is meant provided with perforations or ports. In practice, the perforations are formed in situ using a perforation gun set up to perforating the casing and cement at the desired angle, or by down-hole milling.

The perfs preferably open through the casing pointed directly toward the longitudinal axis of the tubular, angled in the direction of flow of wellbore fluids, so that fluid is emitted from the perf with an axial velocity component along the axis of the wellbore casing. Conventional practice would be to perforate the casing at a right angle from the wellbore axis. The angle (acute side) between the axis of the casing and the axis of the perf can range from 10 degrees to 80 degrees, usually between 20 degrees and 45 degrees, and all of the perfs point in the same direction, preferably at the same angle. The obtuse angle A shown in the drawing is 180 degrees minus the acute angle. The design in cross section appears as a "herring bone" pattern. The situation can be analogized to merge ramps on a highway. Most highways have entrance and exit ramps that merge smoothly in to and out of traffic. That is, the entrance and exit ramps are not perpendicular to the highway. As a result, with the exception of some

courteous yielding, vehicles are capable of entering and exiting a highway without slowing down the speed of the other cars on the highway.

For maximum effectiveness, the number of slanted perforations would need to be limited. In conventional vertical completions, it is common to have a perforation density of four shots per foot (spf). However, this density can be reduced to 1 or 1/2 spf for a horizontal well without significantly affecting the well's productivity, and under good formation conditions, can be even further apart. By reducing the number of entry points for the flow into the wellbore, there is less interference of the fluid flowlines in the wellbore. Choosing the optimum perforation density requires balancing the tradeoff of maximizing reservoir access while minimizing the flow interference in the wellbore.

Axial perfs will provide lower flow resistance per unit length of casing than normal perfs, all other things being equal. Flow resistance per unit length along the perforated section of the casing can be further reduced by reducing the perf diameter, reducing the number of perfs per unit length, and incrementally changing the position of the axial perfs on the circumference of the casing between adjacent longitudinal positions, so as to bring in the influx flow streams through the perfs from locations around the entire periphery of the casing in a cyclical, crankshaft-layout-type fashion. Where the axial perfs are employed in groups, it is expected that the groups will be positioned in areas best described as circumferentially-extending strips or banks.

The industry has developed techniques designed to maximize the penetration and size of a perforation charge. The primary measures of perforation performance are defined as the depth of penetration and perforation tunnel diameter. In order to achieve the current state-of-the-art performance requires shooting the perforation charges at a right angle from within the wellbore. Changing the inclination of the perforation guns will influence the depth of penetration.

Further details of preferred embodiments

The casing will generally have an inside diameter of from about 2 inches to about 15 inches (50 mm to 375 mm). The wall thickness of the casing can vary over a wide range, but will usually be in the range of about 5/64ths to 1 inch (2 to 25 mm). The perfs will generally have a diameter of less than about 30% of the casing inside diameter, usually less than 20% of the casing diameter, and frequently less than 10% of the casing diameter. Where the casing is set in cement, the perforations extend through the cement and into the formation.

Where the perfs are deployed in banks, each bank will generally contain in the range of from 1 to 20 perfs, usually in the range of from 2 to 12 perfs. The banks are preferably separated by a phase angle in the range of from about 30 degrees to about 180 degrees, usually in the range of from 45 degrees to 120 degrees, as measured between the centers of the banks, and a distance as measured longitudinally between the banks in the range of from 0.5 to 10, usually 1 to 5, times the inside diameter of the casing.

A design consideration for the angled fluid influx casing is reducing the perforation diameter to allow greater control in terms of customizing the orientation and inclination of the openings in the casing. This greater control increases the ability to merge the influx flow streams with the wellbore flow streams. However, the invention is equally applicable to currently oil industry practices in terms of perforation diameters and phasing of the perforation holes. As a further measure of reducing flow resistance, clusters of perforations can be spaced apart from other clusters. The clusters of perforations can be spaced several feet apart, depending on reservoir characteristics, for example, every one to two feet, or more. The actual dimensions and relative position of the stream-perforations will depend on milling limitations, costs, laboratory tests and well specific data. The casing is preferably perforated only in locations positioned in the production zone.

The casings of the invention can be used with conventional completion techniques as are well known by those skilled in the art. For example, the casing can be used in vertical, highly

deviated or horizontal wells. However, the invention is expected to provide its greatest benefit when used in wells having a lengthy completion interval, such as in a horizontal well, or multiple completion intervals.

While certain preferred embodiments of the invention have been described herein, the invention is not to be construed as being so limited, except to the extent that such limitations are found in the claims.

CLAIMS

What is claimed is

1. A well 2 for the production of hydrocarbons, comprising

a well bore 4 extending into the earth from the surface of the earth into a hydrocarbon production zone 6, and

a well bore casing 8 positioned in the borehole, said well bore casing having a longitudinal axis, a generally annular cross section across the longitudinal axis, a wellhead end, a well bottom end, and a plurality of perforations 10 opening through a sidewall of the casing along a segment of the casing positioned in the hydrocarbon production zone which form plurality of flow paths from an outer surface of the casing to an inner surface of the casing, said perforations being formed through the sidewall at an obtuse angle A with respect to the longitudinal axis of the casing in the direction of the wellhead end so that substantially all hydrocarbon flowing from the hydrocarbon production zone and into the casing exits the perforations with a substantial axial velocity component toward the wellhead end of the casing.

2. A well as in claim 1 further comprising
a cement layer 12 which lines the wellbore at least across the hydrocarbon production zone, said cement layer being positioned between the well bore casing and the earth and being perforated by the perforations to permit hydrocarbon to flow from the earth, though the cement layer, into the well bore casing and to the surface of the earth.

3. A well as in claim 2 wherein the cement is positioned in an annulus between the casing and the well bore.

4. A well as in claim 1 which is highly deviated from vertical in the production zone.

5. A well as in claim 1 wherein the well bore casing is substantially imperforate apart from the segment of the casing positioned in the hydrocarbon production zone.

6. A well as in claim 1 in which the perforations have a diameter which is less than about 30% of the casing diameter.

7. A well as in claim 1 in which the perforations have a diameter which is less than about 20% of the casing diameter.

8. A well as in claim 1 in which the perforations have a diameter which is less than about 10% of the casing diameter.

9. A well as in claim 1 wherein the casing has an inside diameter, and the perforations are arranged in a series of longitudinally separated banks, and the longitudinally separated banks of perforations are separated by a longitudinal distance which is in the range of from about 0.5 to about 10 times the inside diameter of the casing.

10. A well as in claim 9 wherein the perforations are arranged in a series of circumferentially separated banks of perforations, each bank containing a portion of the plurality.

11. A well as in claim 10 wherein adjacent banks are separated by an angle in the range of from about 30 degrees to about 180 degrees, as measured between bank centers through the longitudinal axis of the casing.

12. A well as in claim 10 wherein adjacent banks are separated by an angle in the range of from about 45 to about 120 degrees, as measured between bank centers through the longitudinal axis of the casing.

13. A well as in claim 1 wherein the obtuse angle with respect to the longitudinal axis of the casing is in the range of from about 100 to about 170 degrees.

14. A well as in claim 1 wherein the obtuse angle with respect to the longitudinal axis of the casing is in the range of from about 135 to about 160 degrees.

ABSTRACT OF THE DISCLOSURE

A completion casing for a well for the production of hydrocarbons is provided with angled perforations through the casing sidewall which reduce flow resistance along the length of the casing.

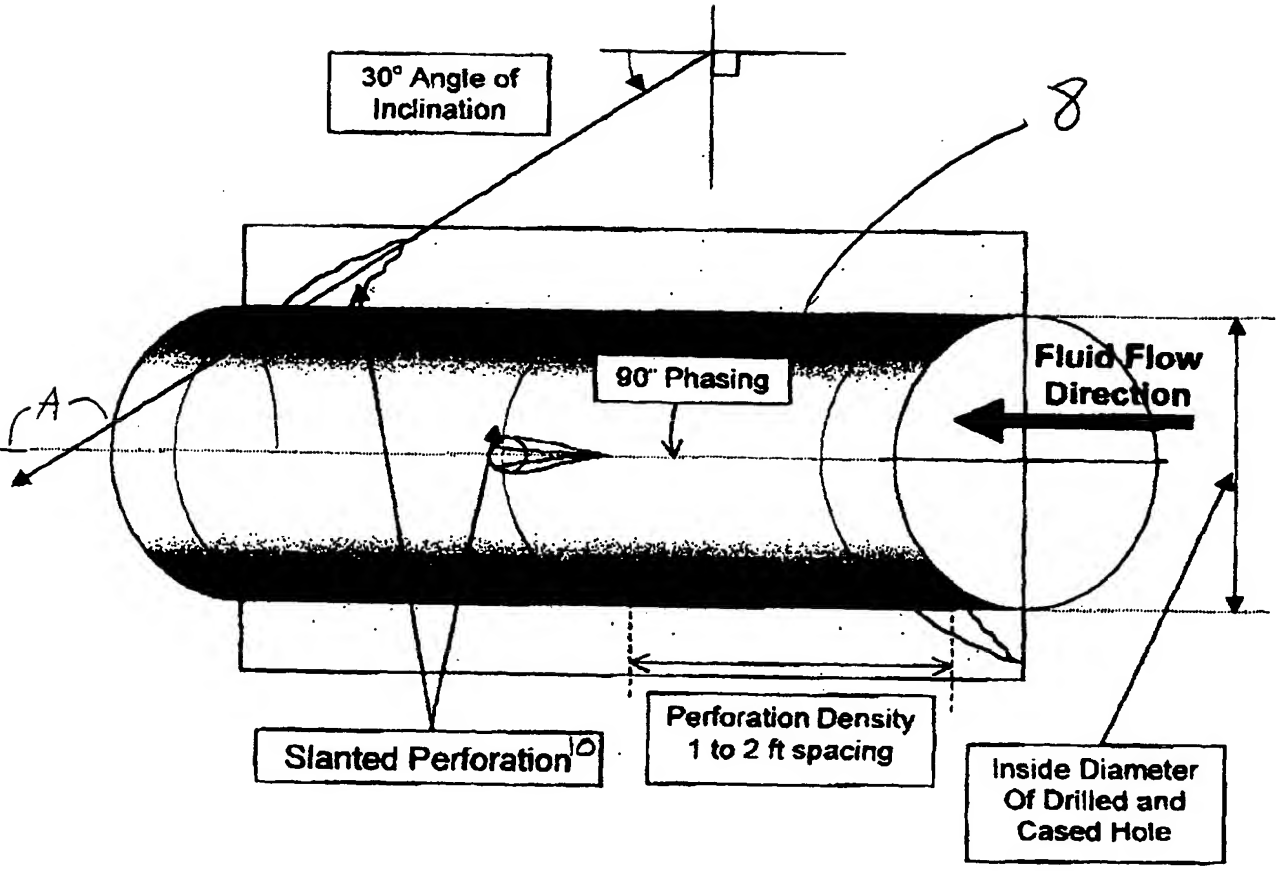
30° Angle of Inclination
8
A
90° Phasing
Fluid Flow Direction
Slanted Perforation
10
Perforation Density 1 to 2 ft spacing
Inside Diameter Of Drilled and Cased Hole

FIG 1

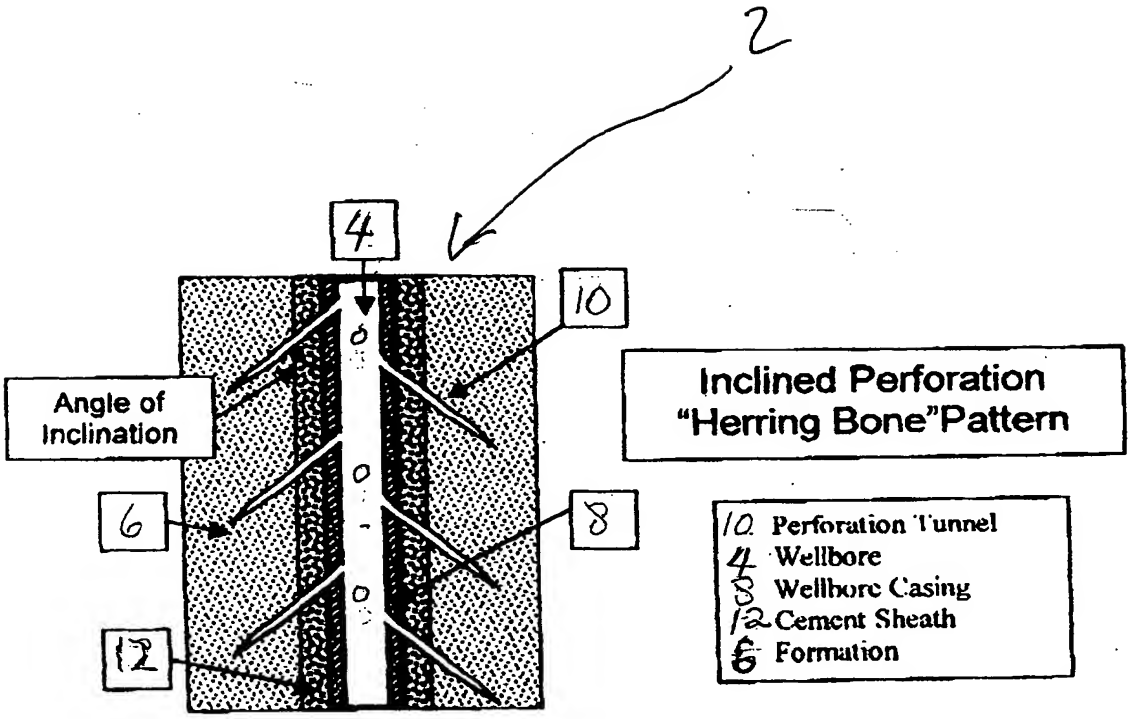

FIG 2

Document made available under the Patent Cooperation Treaty (PCT)

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World Intellectual Property Organization (WIPO) - Geneva, Switzerland
Organisation Mondiale de la Propriété Intellectuelle (OMPI) - Genève, Suisse